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Ministry of the ENVIRONMENT

Guidelines for Conducting Treatability Studies for Phosphorus Removal at Wastewater Treatment Plants

1972

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GUIDELINES FOR CONDUCTING TREATABILITY STUDIES FOR PHOSPHORUS REMOVAL AT WASTEWATER TREATMENT PLANTS

An information brief for consulting engineers and municipal officials and a supplement to Guidelines for Initiating Treatability studies. Further information can be obtained by contacting Mr. J.W.G. Rupke or Mr. G. L. Van Fleet.

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- NOTICE -

This information brief does not purport to suggest that the described methodology is the only approach which can be taken in investigating the most economical method of phosphorus removal at a municipal waste water treatment plant. It describes a method which has proven extremely successful and which has the flexibility for modification to suit the particular plant being studied.

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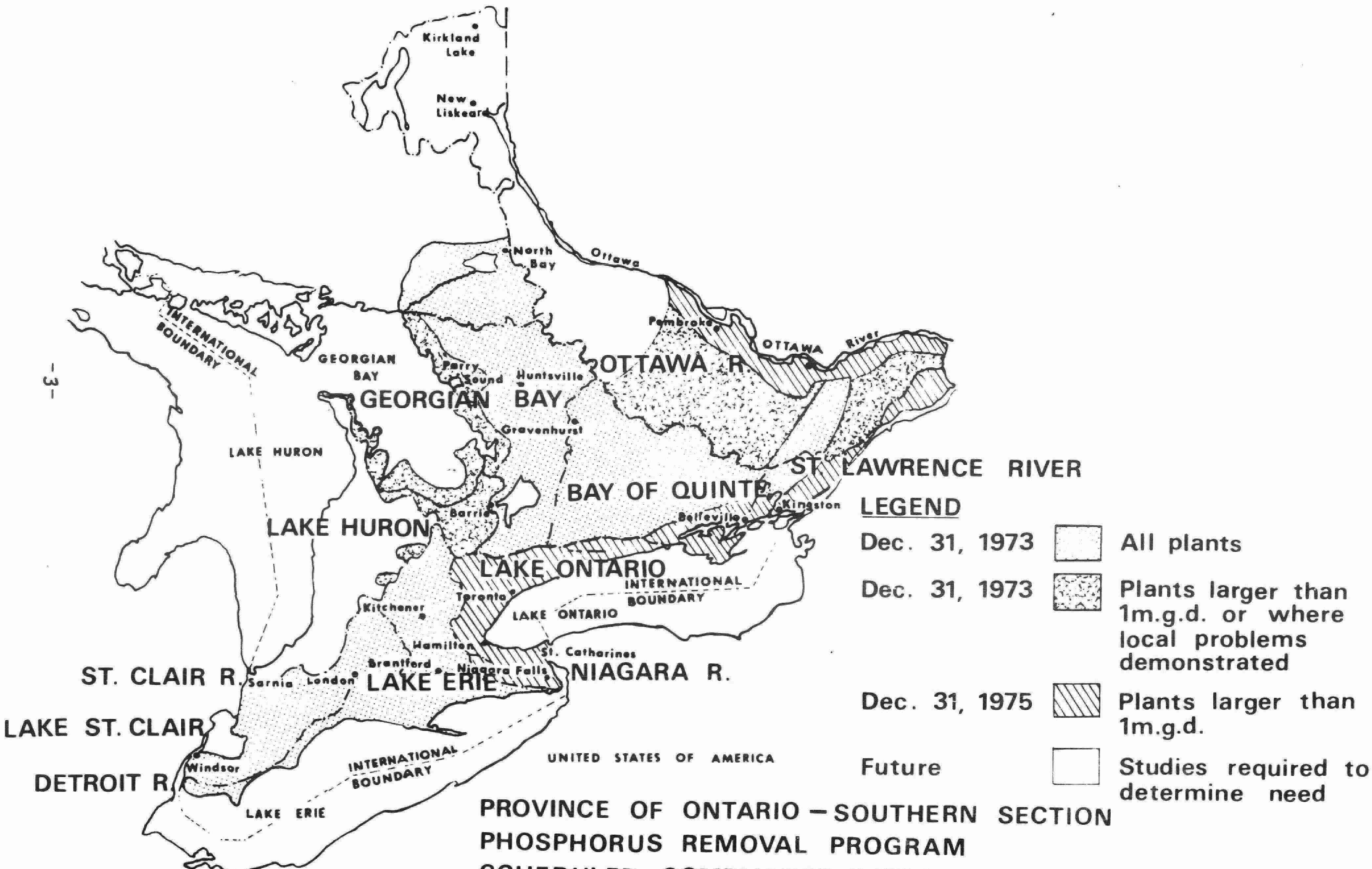
GUIDELINES FOR CONDUCTING TREATABILITY STUDIES FOR PHOSPHORUS REMOVAL AT WASTEWATER TREATMENT PLANTS

INTRODUCTION

Nutrients are known to play a significant role in the growth and proliferation of algae in the aquatic environment. The control of specific nutrient inputs, such as phosphorus, can aid in correcting existing eutrophication problems and protect our waterways from over-abundant algal production.

The Province of Ontario is presently involved in a five-year program to control, by 1975, phosphorus discharges from more than two hundred existing wastewater treatment plants serving some 4.7 million persons. Permanent phosphorus removal facilities must be operational by December 31, 1973, in the most critically affected areas of the Province; by December 31, 1975, for those discharging to waters deemed to be in a less critical condition; and three years after notification in all other areas of the Province where problems are found to exist or where protective measures are required. Figure I outlines the areas of the Province affected by the program and the respective compliance dates. The program is a response to International Joint Commission recommendations on the lower Great Lakes and the demonstrated need for nutrient controls in prime recreational waters throughout the Province.

Figure 1



PROVINCE OF ONTARIO – SOUTHERN SECTION
PHOSPHORUS REMOVAL PROGRAM
SCHEDULED COMPLIANCE DATES

Affected wastewater treatment plants located in the Upper Great Lakes and Ottawa River Systems are required to remove 80 per cent of the phosphorus from sewage which enters the treatment plant. An average effluent total phosphorus concentration of 1 mg/l is required at all affected plants which discharge directly or indirectly to the St. Clair River, Lake St. Clair, the Detroit River, Lake Erie, the Niagara River, Lake Ontario and the Ontario section of the St. Lawrence River. The permanent facilities and prime chemical coagulant selected must, in each case, be capable of greater removal efficiencies, as further receiving water studies may dictate the need for more stringent requirements.

GUIDELINE OBJECTIVES

These guidelines are designed to assist personnel involved in carrying out phosphorus removal treatability studies in determining the most efficient and economical means to implement phosphorus removal through chemical addition at existing wastewater treatment plants. The methodology, which includes both jar testing and pilot study phases, would allow the prediction of the prime coagulant best suited for phosphorus removal at any particular treatment facility and a determination of whether the chemical used would have any effect on the existing wastewater treatment process, facilities, method of sludge treatment, and subsequent sludge disposal practices. The choice of chemical would be limited to the process most compatible with sewage characteristics and the existing facilities, taking into account the physical layout of the plant and the delivered cost and availability of the particular chemical. As it has been established that raw sewage characteristics vary from

municipality to municipality, the need for a treatability study at each plant is evident. In some cases it may be sufficient to accurately predict the most suitable chemical for a particular plant on the basis of jar testing studies alone.

PROCEDURES

Initial work consists of preliminary jar tests to establish the prime precipitant (iron, aluminium, or calcium salts) that will consistently provide the degree of phosphorus removal required. The jar testing should cover the equivalent of three one-week periods of intensive testing using each of the chemicals throughout the day and in the various days of the week. Analyses should be conducted on raw samples and the supernatants from the jars. Through the use of probability plots, comparative chemical dosages and costs can be obtained. This information in conjunction with an assessment of the visual and analytic data obtained during the study and a knowledge of the existing plant facilities can provide a base for predicting the most suitable chemical.

An interim study report should be prepared and submitted based on the jar tests and include sufficient data to substantiate the conclusions reached. This report may also include a recommendation for a full-scale pilot study using the most efficient chemical. Such a recommendation should be contingent upon a site evaluation to determine if existing facilities can be readily used for phosphorus removal in the manner which is proposed.

When the interim study report is reviewed and approved, a full-scale pilot study may be carried out. The study can frequently be run on a portion of the plant and produce results equivalent to the complete plant at substantial savings. Prior to commencing the full-scale study, the various points of chemical application should be assessed to ensure that adequate mixing capability is present in the existing plant. Mixing may be obtained through chemical discharge into the suction side of pumps, in an aerated grit chamber, into interconnecting channels or into the aeration tank. In most cases it will not be necessary to utilize flash mixers.

If full-scale tests are to be conducted, it is expected that the studies would be of approximately six weeks duration for a primary treatment plant. For a secondary treatment plant, eight weeks of full-scale operation should yield the required information. Following completion of the full-scale studies, a complete treatability study report is to be prepared, documenting problems encountered at the plant, confirming the chemical to be used in permanent operation and containing recommendations for the implementation of phosphorus removal.

Phase I - Jar Testing

The use of jar testing procedures to simulate water treatment plant conditions is a well known and often used technique (1). More recently this same jar test procedure has been used to provide preliminary design

(1) Simplified Procedures for Water Examination. AWWA Manual, M12, p. 42.

information on phosphorus removal by chemical precipitation in municipal wastewater treatment systems. Tests are carried out on grab samples of either the raw sewage or final effluent (see Appendices A and B). For primary plants,varying dosages of aluminum salts, iron salts and lime are added to raw sewage samples. Tests on biological treatment units are carried out using aluminum and iron salts applied to the final effluent which produces results similar to those obtained from chemical application to the mixed liquor. When primary and biological units are in operation both of the aforementioned tests are carried out.

The procedure, which parallels that used by the potable water treatment plant operators (1), is described as follows:

1. *Adopt a jar test procedure which must be continued throughout the test programme at the plant. Use a standard arbitrary timing sequence ensuring adequate mixing and reaction time,* [*e.g. 5 minute fast mix (100 rpm) followed by 15 minute slow mix (25 rpm), settle for 30 minutes and sample supernatant*].

2. *Take a 7 litre grab sample of the waste stream to be tested.*

3. *Retain a well mixed 1 litre raw sample of the above for measurement of total phosphorus and pH. Occasionally check soluble phosphorus, suspended solids and BOD (see step 8).*

4. *Fill six one litre beakers and place them under the multiple stirring apparatus.*

5. *Dose beakers 2-6 with varying dosages of the chemical selected, covering the initial ranges listed in Table I. Beaker no. 1 is a control and receives no chemical.*

<u>Table I</u>

Chemical		Dosage Ranges (mg/l)
Common Name	Chemical Formula	
Alum	$Al_2(SO_4)_3 \cdot 14H_2O$	75 - 300
Ferric Chloride	$FeCl_3$	5 - 30*
Lime	$Ca(OH)_2$	75 - 300
*as Fe^{+++}		

Add the selected chemical dosages to each beaker in succession while running the mixer at 100 rpm. It is important that the chemicals be added as rapidly as possible. Continue to operate at this high speed after the last chemical addition to provide the required fast mixing time.

6. *Adjust the mixer speed to slow mix in accordance with the procedure adopted in step 1. and allow to run for the required slow mixing time.*

7. *During the slow mix and subsequent settling period record the following visual observations (a sample laboratory data sheet and instructions are attached as Appendix C):*

- *a comment on the time required for flocculation to take place. (slow, fast, etc.)*
- *floc size after flocculation time. (small, medium, large)*
- *floc settling characteristics. (slow to fast)*
- *supernatant quality. (turbid to clear)*
- *volume of sludge produced.*

8. *Analyze the well mixed raw sample and each of the jar supernatants, including the control sample, for total phosphorus and pH. Occasionally check soluble phosphorus, suspended solids and BOD on samples; generally each of these additional analyses should not exceed 10 per cent of the number of total phosphorus analyses carried out.*

9. *Repeat steps 2. to 8. ignoring Table I, using fresh samples of wastewater to narrow down the range of chemical dosages used. The rationale for choosing subsequent dosages involves attempting to bracket the range of removal efficiency or effluent quality required by selecting one dosage lower than the objective, one near the objective and one higher than the objective. (i.e. if the initial tests using alum, ferric chloride and lime showed phosphorus removals as listed in Table II, the indicated changes would be made in subsequent tests) At the present time the objective is either 80 per cent removal or 1 mg/l effluent total phosphorus depending upon the particular drainage basin basin into which the plant discharges. This has been discussed previously.*

Table II

Chemical	Dosage (mg/l)	Total P Removal (%)	Total P in Jar Supernatant (mg/l)	Dosages to be used in Subsequent Tests (mg/l)
Alum	100	45	2.5	
	150	70	1.5	150
	200	85	1.0	200
	250	95	0.8	250
	300	98	0.8	
Ferric Chloride	5*	78	1.3	4*
	10*	89	1.0	7*
	15*	95	0.8	10*
	20*	97	0.8	
	25*	98	0.8	
Lime	100	30	3.5	
	150	65	1.7	
	200	73	1.4	200
	250	84	1.1	250
	300	87	1.0	300
* As Fe^{+++}				

It is essential that the jar tests be carried out over an extended period of time, preferably of three weeks duration, in order that a wide and representative variety of sewage characteristics are encountered. Grab samples should be taken at different times of the day and on various days of the week. Once the range of chemical dosages has been established, do not alter these dosages unless the results show that you are consistently under-dosing or overdosing. In order to have sufficient data to draw meaningful conclusions, it is essential that a minimum of 10 data points are obtained at each chemical dosage on each waste stream being studied. Typical jar testing runs to obtain the necessary data points using low, middle and high chemical dosages are shown in Appendices A and B.

Statistical plots of the data obtained are used to determine the relative chemical dosages. Although in full-scale operation the effectiveness of phosphorus removal is determined on the basis of average plant operating results, for purposes of evaluating jar test data, comparable chemical dosages are obtained at the 80 per cent confidence level on probability curves. Sample probability curves are attached as Appendix D. It should be noted that each curve represents a single chemical dosage into a particular waste stream. Separate graphs would be used for each chemical on each waste stream. The data presented in Appendix D is for illustrative purposes only and should not be taken to suggest that there is a standard correlation between per cent removal and effluent total phosphorus level.

Data Analyses

Rather than looking at the average total phosphorus removal for each set of data, more meaningful information can be gained by plotting each set of 10 points on arithmetic probability paper. This can be done by arranging the data in numerical order of percentage total phosphorus removal from raw sample or supernatant (effluent) total phosphorus concentration. Then plot % total P removal or effluent total P concentration on the ordinate versus $\frac{x}{n + 1}$ on the abscissa

where n = total number of samples
x = sample number, e.g. 1, 2, 3, 4, etc.

When all data are thus plotted a direct comparison can be drawn between the various chemical dosages used. Use a separate graph for plotting the various removal results for each chemical on a particular waste stream.

Two significant aspects of these curves should be considered.

1. *The relative vertical position of the plot lines indicates the degree of effectiveness of the precipitant used at that given dosage.*

2. *The slope of the plot line indicates the degree of certainty or reliability of the chemical in achieving the required results.*

From this analytical data, the relative economics of the various chemical processes for phosphorus removal can be determined on the basis of optimum dosage, delivered cost, and availability of the chemicals.

These data should form part of the interim study report to be completed prior to initiating full-scale studies.

Phase II - Full-scale Pilot Studies

The results of the preliminary jar tests conducted as Phase I of the treatability studies for phosphorus removal will yield a conclusion as to the optimum chemical to be used for phosphorus removal at the particular wastewater treatment plant. Full-scale studies can then be conducted using this prime coagulant to yield information in the following areas:

- *confirm the chemical dosage*
- *optimize the point of application*
- *prove the suitability of plant hydraulics*

- *prove that existing mechanical equipment will operate satisfactorily under the new service conditions*
- *provide data on sludge characteristics*
- *indicate the actual final effluent quality that will be attained*
- *provide total annual operating costs related to phosphorus removal.*

In some special cases, full-scale studies may not be required or even warranted. Previous experience, accumulated technical information, and plant mechanical and process status could all combine to make full-scale studies unnecessary.

If full-scale tests are to be conducted, it is expected that the studies would be of approximately six weeks duration for a primary treatment plant. For a secondary wastewater treatment plant, eight weeks of full-scale operation should yield the required information. Such a study would only involve chemical addition into the waste stream indicated most promising by the jar tests, assuming that addition at this point yielded satisfactory results. Subsequent work in altering the point of application to reduce chemical dosage can be conducted after the full-scale facility is on stream permanently.

An assessment of digester operation during these studies is not considered essential. Flexibility in design of permanent facilities is obviously required.

Under certain circumstances an extended study beyond the time periods previously outlined may be required. The presence of a significant

industrial waste load, e.g. cannery wastes, could necessitate more extensive studies both in the jar testing and full-scale pilot work.

The prime objective of the full-scale temporary phosphorus removal studies is to demonstrate the feasibility of effecting phosphorus removal at a particular installation without necessitating extensive plant modifications or additions. Some of the mechanical plant aspects that may be affected by phosphorus removal are:

- *raw sludge collection and handling capability*
- *return sludge pumping capacity*
- *digester heat exchange capacity.*

Essentially the full-scale studies should demonstrate that phosphorus removal, using the prime coagulant indicated by the jar tests, is compatible with the existing wastewater treatment processes. While effecting phosphorus removal is the prime objective, the study should not be carried out in a manner which might lead to a deterioration in plant effluent quality.

In order to assess plant performance during the study period, an appreciable sampling and analytical work load will result. Under routine conditions it is expected that composite sampling of liquid sewage streams will be conducted a maximum of three times per week. These samples would be analyzed for total phosphorus, soluble phosphorus, BOD, pH, and suspended solids. Grab samples of various sludge streams will be taken several times a week. Expenditures eligible for reimbursement

are only those covering analytical work conducted in addition to normal plant operational analyses.

During a secondary treatment plant study, it is expected that approximately 130 man-hours of laboratory services would be required to handle the necessary analyses; for a primary plant, the manpower requirements for laboratory analyses are estimated at 90 man-hours.

The normal in-plant monitoring required for plant operation should be sufficient to yield the necessary information on the effects of implementing phosphorus removal at the existing wastewater treatment plant. However, if normal in-plant tests are minimal, it is suggested that the following observations be conducted during the study: sludge levels in clarifiers, dissolved oxygen concentrations in aeration tanks, sludge volume index values, and return sludge rates.

A previous outline entitled, "Guidelines for Initiating Treatability Studies for Phosphorus Removal" contained applications and instructions for rebate of treatability study costs. It was pointed out that treatability study equipment purchased specifically for such a study would revert to the Crown if reimbursement for such material was made. In this regard, it is advisable for the operating authority to directly purchase such items as chemical storage tanks and feed pumps suitably sized for use in the permanent facilities; such equipment could then be incorporated into the permanent treatment facility as part of the regular capital costs. Where lime is selected as the prime coagulant

the Ministry will provide, on loan, a package lime feed system for the duration of the full-scale study. Although the use of temporary "swimming pool" type storage tanks is an expedient measure, they have proven unreliable, resulting in uncontrolled spills and the loss of large volumes of chemical.

The manpower costs, exclusive of analytical work, associated with the full-scale studies will arise from three major areas:

- *initial plant inspection and equipment set-up.*
- *technical support for the duration of the study.*
- *sampling and on-site analyses conducted during the study.*

During these studies, technical assistance is available, if required, from the Ministry of the Environment, Research Branch. Having conducted many full-scale phosphorus removal studies, staff can provide information both during initial plant set-up and in assessing operating problems that may occur during the study. In any case, if operating problems are encountered during a phosphorus removal study, it is essential that the Phosphorus Programme Co-Ordinator be made aware of the nature of these difficulties. Such contact should ensure that proper operating conditions are being effected during these studies.

The final treatability study report should document the full-scale studies and contain appropriate recommendations to implement phosphorus

removal on a permanent basis without deterioration in existing plant processes. The report must include total annual operating cost estimates for phosphorus removal and the appropriate cost breakdown.

Contributions from the Research, Project Operations and Sanitary Engineering Branches are gratefully acknowledged.

APPENDIX A

PHOSPHORUS REMOVAL PROGRAM — JAR TESTING PROCEDURES

SAMPLE RUN Nº							
1.	S_1	C_1	A_L	A_M	A_H	F_L	F_H
2.	S_2	C_2	F_L	F_M	F_H	L_L	L_H
3.	S_3	C_3	L_L	L_M	L_H	A_L	A_H
4.	S_4	C_4	F_L	F_M	F_H	L_L	L_M
5.	S_5	C_5	L_L	L_M	L_H	A_L	A_M
6.	S_6	C_6	A_L	A_M	A_H	F_L	F_M
7.	S_7	C_7	L_L	L_M	L_H	A_M	A_H
8.	S_8	C_8	A_L	A_M	A_H	F_M	F_H
9.	S_9	C_9	F_L	F_M	F_H	L_M	L_H
10.	S_{10}	C_{10}	L_L	L_M	L_H	F_L	F_H
11.	S_{11}	C_{11}	F_L	F_M	F_H	A_L	A_H
12.	S_{12}	C_{12}	A_L	A_M	A_H	L_L	L_H
13.	S_{13}	C_{13}	F_L	F_M	F_H	A_L	A_M
14.	S_{14}	C_{14}	A_L	A_M	A_H	L_L	L_M
15.	S_{15}	C_{15}	L_L	L_M	L_H	F_L	F_M
16.	S_{16}	C_{16}	A_L	A_M	A_H	L_M	L_H
17.	S_{17}	C_{17}	L_L	L_M	L_H	F_M	F_H
18.	S_{18}	C_{18}	F_L	F_M	F_H	A_M	A_H

Note: This series would be used in assessing raw sewage at a plant where there are primary clarifiers.

This is a typical series of jar testing runs considering all three chemicals with low, middle and high dosages of each chemical. Note that this series utilizes 18 different grab samples of the waste stream and produces 10 results for each chemical dosage. This number will take into account variations in the waste stream and provide minimum data for statistical plots.

The symbols designate the following:

S = waste stream sample with no chemical added (for immediate analyses of unsettled sample)
C = control sample with no chemical added (for analyses on supernatant after jar test)
A_L = low alum dosage
A_M = middle alum dosage
A_H = high alum dosage
F_L = low ferric chloride dosage
F_M = middle ferric chloride dosage
F_H = high ferric chloride dosage
L_L = low lime dosage
L_M = middle lime dosage
L_H = high lime dosage

APPENDIX B

PHOSPHORUS REMOVAL PROGRAM – JAR TESTING PROCEDURES

SAMPLE RUN Nº							
1.	S_1	C_1	A_L	A_M	A_H	F_L	F_H
2.	S_2	C_2	F_L	F_M	F_H	A_L	A_H
3.	S_3	C_3	A_L	A_M	A_H	F_M	F_H
4.	S_4	C_4	F_L	F_M	F_H	A_M	A_H
5.	S_5	C_5	A_L	A_M	A_H	F_L	F_M
6.	S_6	C_6	F_L	F_M	F_H	A_L	A_M
7.	S_7	C_7	A_L	A_M	A_H	F_L	F_H
8.	S_8	C_8	F_L	F_M	F_H	A_L	A_H
9.	S_9	C_9	A_L	A_M	A_H	F_M	F_H
10.	S_{10}	C_{10}	F_L	F_M	F_H	A_M	A_H
11.	S_{11}	C_{11}	A_L	A_M	A_H	F_L	F_M
12.	S_{12}	C_{12}	F_L	F_M	F_H	A_L	A_M

Note: This series would be used in assessing

a) unchlorinated final effluent at all biological treatment plants;

b) raw sewage at plants where there are no primary clarifiers;

c) raw sewage at aerated and conventional waste stabilization ponds (continuous discharge facilities).

This is a typical series of jar testing runs considering only alum and ferric chloride with low, middle and high dosages of each chemical. This series utilizes 12 different grab samples of the waste stream and produces 10 results for each chemical dosage. This number will take into account variations in the waste stream and provide minimum data for statistical plots.

S = waste stream sample with no chemical added (for immediate analyses of unsettled sample)

C = control sample with no chemical added (for analyses of supernatant after jar test)

A_L = low alum dosage

A_M = middle alum dosage

A_H = high alum dosage

F_L = low ferric chloride dosage

F_M = middle ferric chloride dosage

F_H = high ferric chloride dosage

APPENDIX C

INSTRUCTIONS FOR USING THE LABORATORY DATA SHEETS

The primary purpose of this form is to provide a worksheet for both the jar tests and the subsequent phosphorus analyses. It can also be used for reporting the results of the jar tests.

Concentrations of the stock solutions used should be recorded (e.g. Alum 50 gm/l). Note that 1 gm per litre = 1 mg per ml so that calculation of the amount of stock chemical to be used for a given dosage is minimal. For instance, using alum at 50 gm/l, for a dosage of 150 mg/l would be 150/50 = 3 ml per litre of sewage.

Mixing times will normally be the standard 100 rpm rapid mix for 5 minutes, 20 - 30 rpm slow mix for 15 minutes and 30 minute settling time. There may arise in the future, the need to change these times, therefore a record must be kept to distinguish the two sets of results. Provision has been made on the form to record the time each of these jar testing stages was started if no interval timer is available.

JAR TESTS

The first three rows, "CHEMICAL(S) USED", "DOSAGE", and "ml of chemicals used" can be filled in prior to the start of the jar tests. The line "ml of chemicals used" is provided so that the volumes of chemical required can be determined and noted prior to commencement of the jar test.

The time of appearance of a floc after start of the slow mix (flocculation) stage will be helpful in plants where flocculation facilities are limited.

The floc size should be recorded after the mixer is stopped (i.e., at commencement of the half hour settling period). Since no physical measurement of floc size will be taken, the terms are somewhat subjective and relative. The sizes, however, should be described in standard terms -

ie: very large - the floc being large masses

large -

medium -

small -

no floc - a condition that might be found in tests on final effluent.

Settling rates will also be described in relative terms -

ie:	Very rapid -	all floc collects immediately on the bottom of the beaker when the mixer is stopped
	Rapid -	floc settles within several minutes of the mixer being stopped
	Medium -	floc take no more than 10 minutes to settle
	Slow -	requires most of settling time
	Nil -	no discernable settling

Turbidity will be described in relative terms; the effect of colour, if any, should be disregarded. The terms used should be -

ie:	Very turbid -	difficult (or impossible) to see through beaker under normal room light

Turbid - large shapes discernable through beaker

Hazy -

Slightly Hazy -newspaper can be read through beaker

Clear - like drinking water

The colour of the supernatant liquid should be recorded, not the colour of the sludge.

pH measurements since they take little time, should be done on all six beakers. It will be necessary to record the temperature of only one of the beakers.

Soluble phosphorus analyses should be performed on-site to eliminate the possibility of post-precipitation.

Reduction in concentration of soluble phosphorus is based on the soluble phosphorus content of the control;

$$\text{i.e., \% reduction} = \frac{\text{control-dosed sample}}{\text{control}} \times 100\%$$

Reduction of total phosphorus is based on the original sample;

$$\text{i.e, \% reduction} = \frac{\text{original-dosed sample}}{\text{original}} \times 100\%$$

Provision has been made on the form to record suspended solids and BOD. Only a few of these need to be done (i.e., one or two for each chemical dosage on each waste stream being assessed).

LABORATORY DATA SHEET

JAR TESTS - PHOSPHORUS REMOVAL

PLANT .... DATE SAMPLED ....

SAMPLE DESCRIPTION .... TIME SAMPLED ....

REAGENTS USED CONCENTRATION

....gm/l RAPID MIX at........rpm for........minutes. Time started ....

....gm/l SLOW MIX at........rpm for........minutes. Time started ....

....gm/l SETTLING before analysis for........minutes. Time started ....

	RUN NUMBER	S	C	2nd JAR	3rd JAR	4th JAR	5th JAR	6th JAR
JAR TEST	CHEMICAL(s) USED (in order of addition for 2 or more)	ORIGINAL SAMPLE	CONTROL					
	DOSAGE in mg/l							
	ml of chemical used							
	APPEARANCE of FLOC (minutes after start of slow mix)							
	Floc size after slow mix							
	Settling rate							
	Turbidity							
	Colour							
	pH							
	Temperature							

SOLUBLE PHOSPHORUS	Volume of sample used							
	Diluted to							
	Absorbance (spectrophotometer reading)							
	mg/l P (from graph)							
	mg/l P in sample							
	% reduction							

TOTAL PHOSPHORUS	Volume of sample digested							
	Diluted to							
	Volume of above used							
	Diluted to							
	Absorbance (spectrophotometer reading)							
	mg/l P (from graph)							
	mg/l P in sample							
	% reduction							

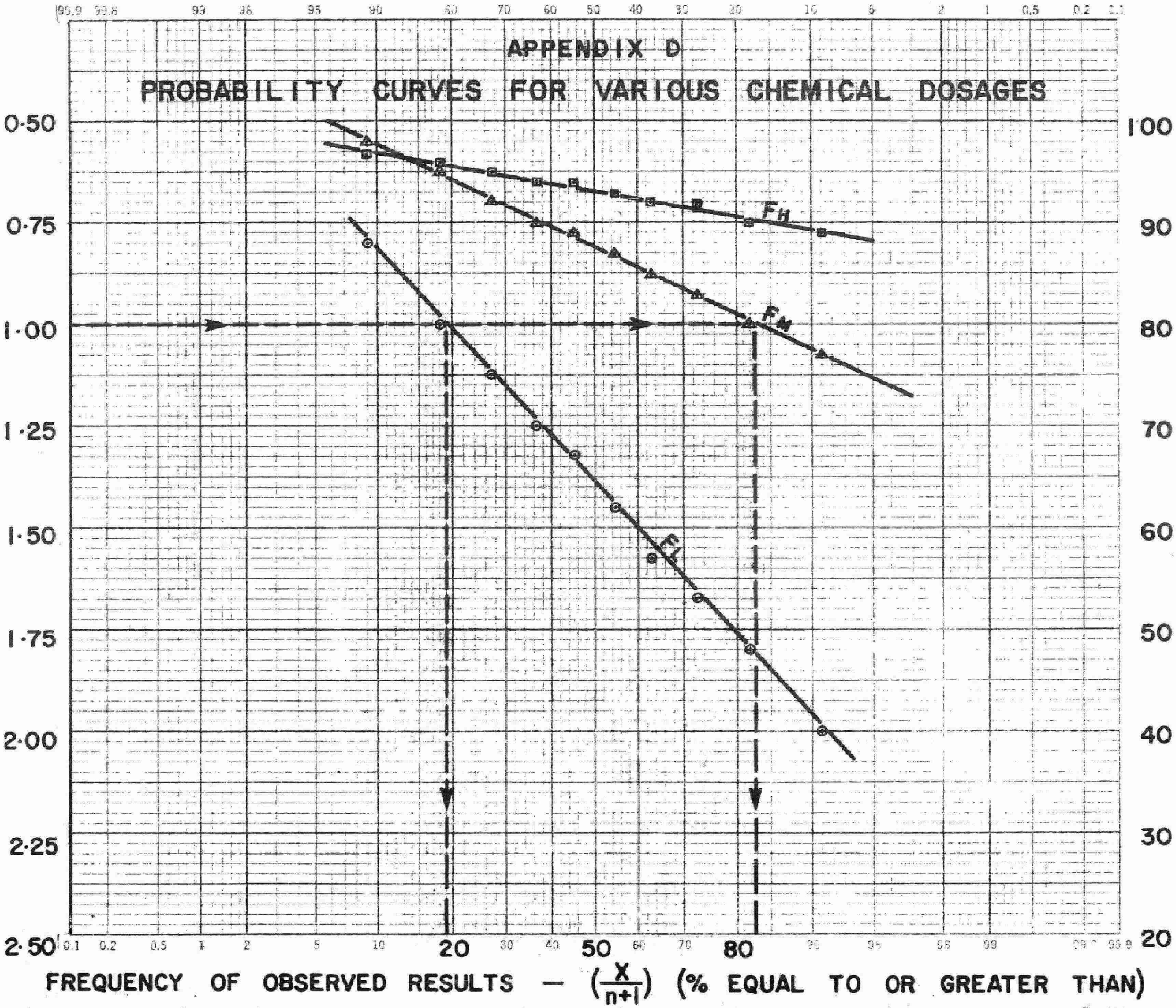
OTHER ANALYSES	Suspended solids - mg/l							
	Volatile suspended solids-%							
	BOD							

REMARKS:

FORM 11-002

APPENDIX D

PROBABILITY CURVES FOR VARIOUS CHEMICAL DOSAGES



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